

Detection of Hydrazine (H) and Monomethylhydrazine or Methyl Hydrazine (MMH) Using Cyranose E-Nose

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Abstract: The Cyranose™ electronic nose (e-nose) has been used for the first time to detect hydrazine (H) and monomethyl hydrazine (MMH). The concentrations of hydrazine chosen in this study were 52 ppm (parts per million), 18 ppm, and 1.1 ppm and the concentrations of MMH was 14 ppm and 1 ppm. The Cyranose E-nose has detected hydrazine of 52 ppm and 18 ppm with a good response. The response of the E-Nose for 1.1 ppm hydrazine was insignificant. The response of E-Nose for 14 ppm MMH was significant and 1 ppm MMH was reasonably identifiable. The Cyranose E-Nose may be used to detect hydrazine and MMH with concentrations of at least 18 ppm and 1 ppm, respectively.

Introduction: The Cyranose™ electronic nose has been developed utilizing conductive polymer (CP) composite materials to recognize a variety of chemical vapors or classes of vapors by creating a fingerprint of each vapor. The principle of detecting chemical vapors is not new but its use for the detection of hydrazine (H) and monomethyl hydrazine (MMH) is novel. We are assessing and evaluating the reliability of commercial-off-the-shelf (COTS) electronic noses and their respective advanced electronic packages in various environments. The goal of this work is to infuse these technologies into future NASA projects and missions and to assure the safety of personnel aboard the International Space Station (ISS). It can also be utilized to monitor air-quality in the cabins of the space shuttle, as a part of the Integrated Vehicle Health Management (IVHM) project and other related NASA projects. Air contaminant monitoring in a closed environment, for example, Space Shuttle (SS), ISS and future manned flight projects is essential to the safety and health of astronauts. Air quality in the shuttle is determined by collecting samples during flight and analyzing them post-landing using laboratory instruments. An inexpensive, lightweight, low-power, miniature sensor (Technology Readiness Levels (TRL) of 4-6) capable of identifying contaminants at trace levels real-time would greatly contribute to NASA's projects.

Hydrazine is a colorless, corrosive and highly toxic compound that must not be allowed in the ISS. It is used in aerospace propulsion and power systems and currently used in the Space Shuttle system as a fuel for the auxiliary power units. Propellant plumes surrounding the orbiting Space Shuttle may include hydrazine and other toxic compounds. We are addressing the detection of hydrazine and monomethylhydrazine in the Space Shuttle and Space Station using Commercial-Off-The-Shelf COTS E-Nose technology.

Airborne exposure limit

	Threshold Limit Value	OSHA	SMAC	SMAC
Hydrazine	0.01 ppm or 10 ppb	1 ppm.	4ppm/1hr	0.04 ppm/7days
Monomethylhydrazine	0.01 ppm or 10 ppb	--	0.002ppm/hr	0.002ppm/7days

(SMAC: Spacecraft maximum allowable concentration)

Experimental Results and Discussion: Figure 1 shows a schematic of the test set-up utilized to detect hydrazine and monomethylhydrazine using the Cyranose electronic nose. Figure 1 also shows the schematic of the sensor array employed in the Cyranose E-nose. The Cyranose™ E-Nose was turned on with a baseline purge (zero air) as shown in the initial part of Figure 2. Baseline response was parallel to the x-axis for all the sensors (32 CP sensors) since background contaminant level was too low to obtain a response by the e-nose. Hydrazine was injected into the inlet of the e-nose as shown in Figure 1. Three concentrations of hydrazine were used in this test, which is performed independently. Response of the E-nose was recorded for various concentrations of hydrazine (52, 18, 1.1 ppm hydrazine) as a function of time. Baseline purge response was independent of time until the beginning of hydrazine injection. At the onset of injecting hydrazine (52 ppm) there was a considerable response by the e-nose with reference baseline response. There was only moderate response for 18 ppm hydrazine and an insignificant response for 1.1 ppm of hydrazine. Based on the response results, We could only use the Cyranose to detect hydrazine 18 ppm and higher concentrations.

Similar tests were performed for 14 ppm and 1 ppm of monomethylhydrazine using the similar schematic test set-up shown in Figure 1. Figure 3 shows the response of the e-nose with respect to various concentrations of monomethylhydrazine. There was significant response for 14 ppm hydrazine and a moderate response for 1 ppm as shown in Figure 3. From the data it may be qualitatively inferred that we could effectively use Cyranose for the detection of MMH for greater than 1ppm concentrations.

Conclusion: The Cyranose™ E-Nose has been used to detect 18 ppm or higher concentrations of hydrazine and 1 ppm or higher concentrations of monomethyl hydrazine. This suggests that the Cyranose E-Nose may have a use for detecting Hydrazine and MMH contaminants that occur as a result of some events. The limitation of this E-nose is that it can not be used if the concentration is lower than 18 ppm of hydrazine or 1ppm of monomethyl hydrazine. Further studies are needed to understand the limitations of this E-Nose in detail.

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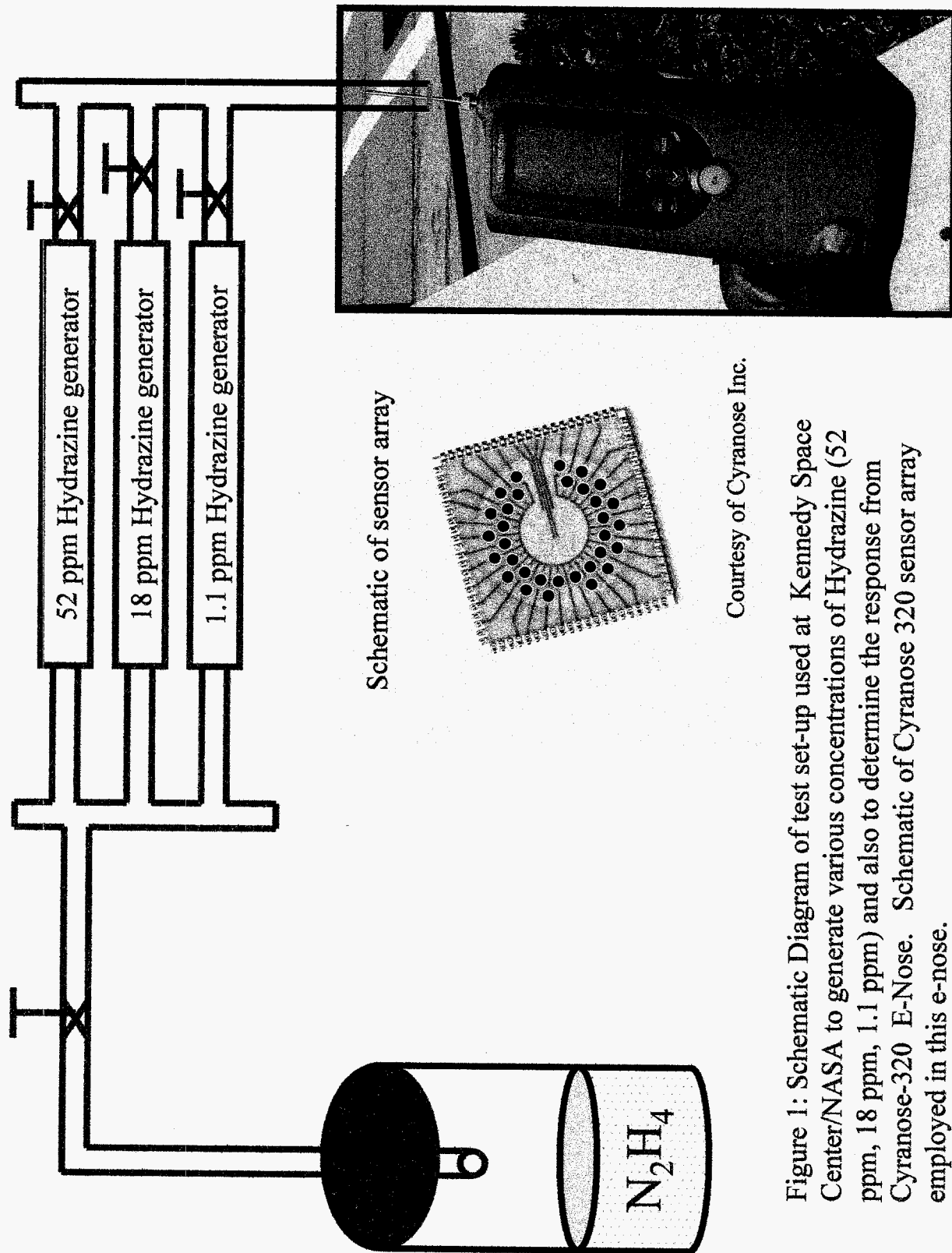
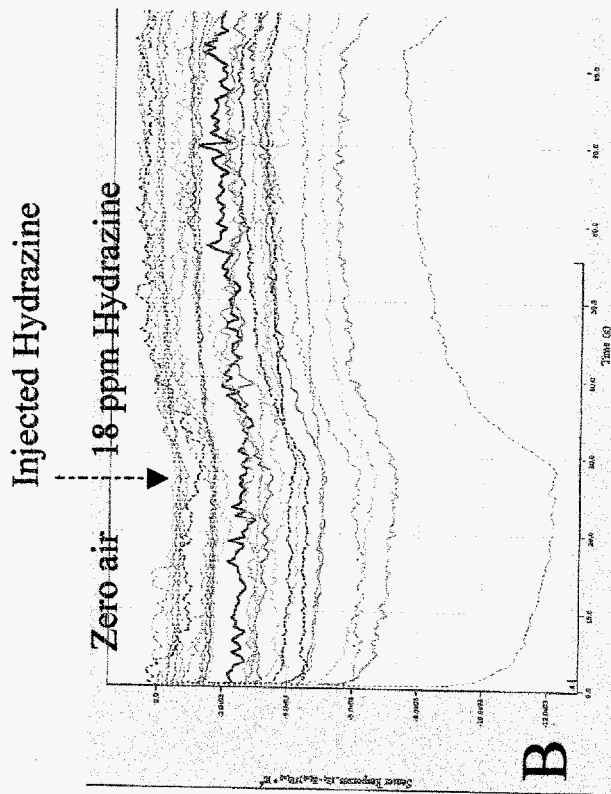
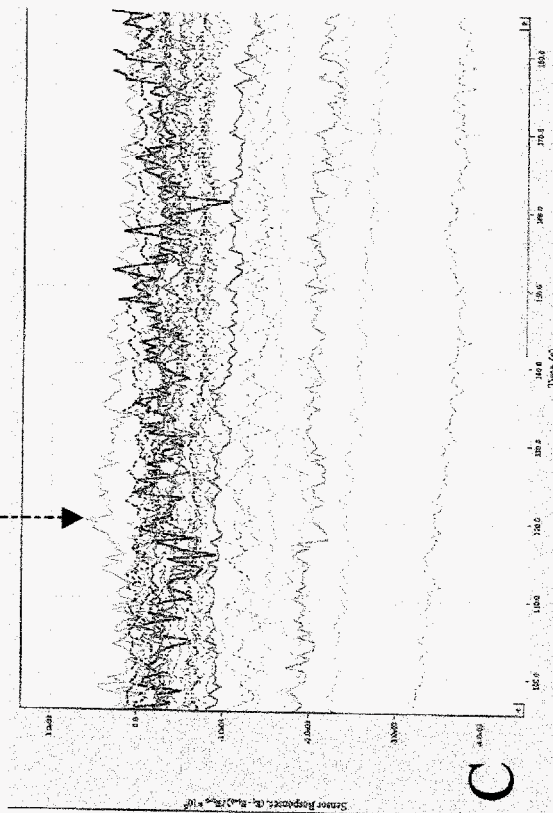


Figure 1: Schematic Diagram of test set-up used at Kennedy Space Center/NASA to generate various concentrations of Hydrazine (52 ppm, 18 ppm, 1.1 ppm) and also to determine the response from Cyranose-320 E-Nose. Schematic of Cyranose 320 sensor array employed in this e-nose.



Disconnected Hydrazine

1.1 ppm Hydrazine



Injected Hydrazine

18 ppm Hydrazine

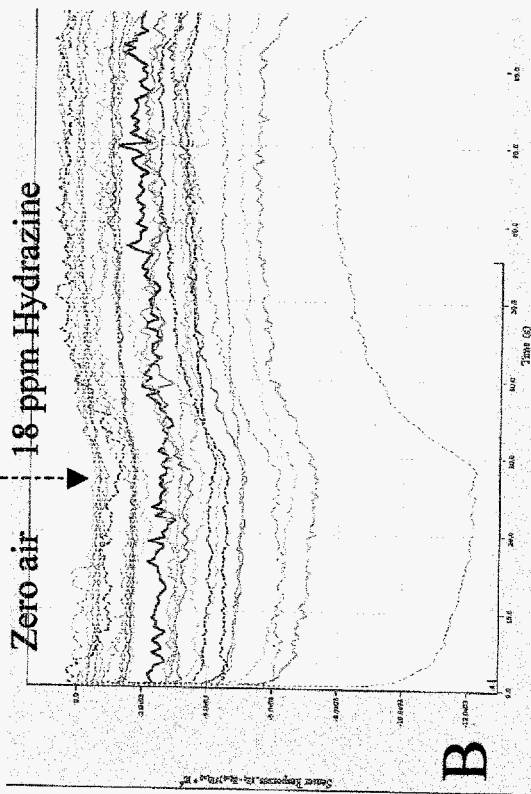


Figure 2: Response of Cyranose E-Nose (consists of 32 conducting polymer sensors) for 52 ppm, 18 ppm, and 1.1 ppm Hydrazine. Each curve is a response from one of the sensors.

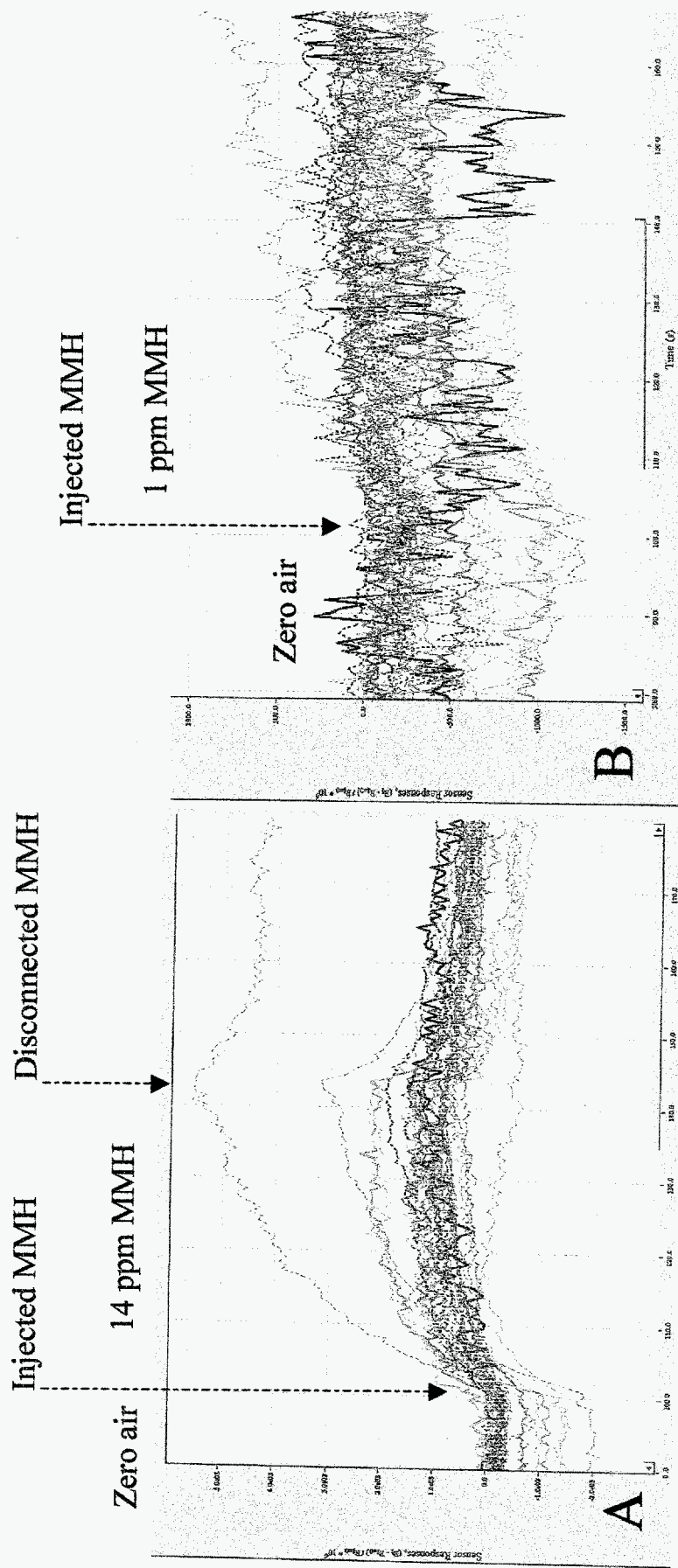


Figure 3: Response of Cyranose E-Nose (consists of 32 conducting polymer sensors) for 14 ppm, 1 ppm, of Monomethylhydrazine (MMH). Each curve is a response from one of the sensors.

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